Mid-Year Product Review

Unlimited possibilities, Unlimited potential.

Tap into your Unlimited potential at Staking UniverSity 5-day classes throughout the year at our campus south of Chicago.

Nationwide, over 25 Locator Certification Seminars a year.

Customized training at your site, anywhere, anytime. DVD's, study guides and online training available.

815.468.7814
www.locatingunlimited.com
The International Locator
Case Studies in the Detection of Non-Metallic Objects

Varying subsurface conditions often present a challenge for utility locating. Conditions such as groundwater table, soil types, fill materials and depth of the buried utilities can limit the performance of both Ground Penetrating Radar (GPR) and Radio Frequency Electromagnetics (RFE). Using an array of different electromagnetic prospecting technologies increases the probability of accurate locates and significantly reduces the chances of hitting an underground structure.

GPR and RFE are great tools for locating buried utilities. But like any other electromagnetic prospecting technology, they have limitations, especially in detecting non-metallic objects such as PVC, HDPE, asbestos cements and other objects. By complementing these technologies with an acoustic locator, the probability of success increases while the risk of damaging a line is greatly reduced.

This paper highlights the use of the SENSIT Ultra-Trac APL (acoustic pipe locator) to detect non-metallic underground utilities in areas where subsurface conditions (clay material/saturated soils) attenuate and limit GPR and RFE response. Three case studies that reflect this situation will be reviewed in this article. Two of the case studies occur at a military facility in southern Puerto Rico, and the third is at GeoEnvirotech’s business premises located in the countryside on the northern side of Puerto Rico.

Puerto Rico GPR Locating Challenges

Soil Types
Puerto Rico is located in the Caribbean area east of the Dominican Republic, where the geology is very complex, having a mixture of soil types that makes the use of electromagnetic prospecting equipment challenging. The island geology consists of volcanic and intrusive rocks in the central region, limestone strips to the north and southwest, and alluvial deposits near the coast. Residual soils consist mostly of clay and sandy clays. GPR’s overall capability in Puerto Rico is limited and considered “low to moderate” due to the mixture of clay and sandy clay soils.

Other challenges
Pipe material type as well as the size and depth of the target lines may render GPR or EM means inept. Some commonly found pipe installation situations in Puerto Rico:

- Old pipe material consisting of ductile iron or steel-easy to find using RF technologies and GPR
- Recent construction sites use PVC pipes that are challenging to locate with GPR due to the presence of sandy clay
- Most storm water pipes are concrete or corrugated polyethylene pipes

GPR Limitations
- Except for sanitary sewer lines, most utilities are within six feet below grade
- Sanitary sewer lines could be more than 20 feet deep

Radio Frequency Electromagnetics (RFE)
RFE is the most common and straightforward approach to detect metallic services or utilities within the subsurface. The technique can be used in two different modes depending upon the type of utility or service being detected. If the service is live, an electromagnetic field is generated by the current flow within the cable, which is detected by the instrument in the passive mode of operation. If the service is not live and can be easily accessed (i.e. at inspection covers and valves), a transmitter unit can be used to directly connect onto the service and induce a signal. The instrument then traces the known signal. The expected depth of penetration using this equipment is typically between six and ten feet.

RFE Limitations
- Interference is possible in areas where services are congested and over areas of reinforced concrete. As a result, it may not be possible to accurately trace and identify the services present
- If the service or utility is not live, the technique relies on the ability to induce a signal through an exposed surface feature (i.e. valve). This is not possible in ceramics, mass concrete or plastic utilities
- The presence of protective coverings, such as insulation flagging or protective tar-based paints, may hinder inducing a signal onto the utility

RFE Strengths
- RFE technology has been proven relatively easy to use and locate energized utilities such as electric and communication wired lines
- RFE is useful for tracing steel/metallic pipes where a direct connection to the utility or induction is possible

GPR Limitations
- Sanitary sewer lines could be more than 20 feet deep
- Except for sanitary sewer lines, most utilities are within six feet below grade
- Sanitary sewer lines could be more than 20 feet deep

GPR Strengths
- Useful in locating trenches, underground storage tanks, PVC or concrete pipes in optimum soil conditions and locating several utilities within a trench

Ground Penetrating Radar (GPR)
Through an antenna, the GPR emits a short burst of radio-frequency energy which detects discontinuities, voids, contact between soil and rock, filled areas, and buried objects such as pipes, drums, etc., using different frequency penetration and resolution rates. Generally, as the frequency increases, the penetration decreases and resolution increases.

The GPR technique involves a short duration, high frequency electromagnetic impulse transmitted into the subsurface. Whenever a contrast in dielectric properties of the subsurface is encountered, some of the transmitted impulse is reflected back to the surface. The strength of the reflected signal is proportional to the magnitude of the contrast in dielectric properties. The propagation (and reflection) of the radar impulse depends heavily on the properties of the groundmass being investigated. Generally, the presence of saturated or clay-rich materials and the presence of reinforced concrete will effectively decrease both the depth penetration and the resolution in the data. An increase in depth penetration and resolution is generally expected within dry, electrically resistive ground.

GPR Challenges
- In busy trenches, RFE response is distorted by magnetic fields generated by adjoining live utilities. Using another technology such as GPR is necessary to identify separate utilities within the trench
- Reinforced concrete slabs can cause significant interference due to tightly spaced rebar, especially when using the inductive mode
- Locating utilities embedded in concrete slabs, since rebar can be easily energized and confused for electric and telecommunication lines

Ground Penetrating Radar (GPR) Strengths
- Useful in locating trenches, underground storage tanks, PVC or concrete pipes in optimum soil conditions and locating several utilities within a trench

Ground Penetrating Radar (GPR) Limitations
- Clay and wet, saturated soils attenuate the GPR signal (Puerto Rico soils consist mostly of silty and clay soils) making detection difficult or impossible
- Overhead structures affect GPR response (canopies, trees, fences, walls, etc.)

SENSIT Ultra-Trac Acoustic Pipe Locator (APL)
The acoustic pipe locator is a relatively new technology. The locator consists of a transponder and a receiver. The transponder sends a low frequency sound wave through the ground that is reflected by the target and re-
GeoEnviroTech decided to try the new detection technology of the SENSIT APL. The APL was able to detect the asbestos cement water line at this facility. Utility location, type, diameter and orientation was confirmed at various locations and documented using vacuum excavation. In order to validate and gain confidence with the APL, it was then used to locate a deep (>12 feet) storm water sewer line located at GeoEnviroTech’s company yard. Due to clay soils and utility depth, GPR was not able to detect the line. The Ultra-Trac APL was able to detect the sewer line and trace it back to the intake headwall. The asbestos cement water line at the military base was located approximately three to four feet below ground. As part of a water development plan at the facility, the actual potable water system had to be identified using geophysics technology in a Quality Level A (QL-A). In this case, the use of conventional RFE locating equipment was not possible since the target material was non-metallic (PVC). Use of GPR was not possible because a PVC water line was located at approximately 14 to 18 inches from a chain-link fence. This fence caused signal interference and affected the GPR response. Also, the fence provided no clearance to run the GPR over the target. However, the SENSIT APL was able to detect the water line, which was later confirmed using vacuum excavation.

According to the equipment manufacturer, SENSIT Technologies, the Ultra-Trac APL operates within the following detection specifications:

**Detection Range**
- Locates ½” pipe to an approximate depth of 12 inches to 30 inches
- Locates 2” pipe to an approximate depth of 12 inches to 48 inches
- Locates 4” pipe to an approximate depth of 12 inches to 96 inches

**Equipment Limitations**
- APL will not detect objects less than 12 inches deep, due to the surface wave
- Accuracy is within +/- 18 inches, plus the slice distance
- The APL does not measure depth, however a depth conversion chart may be used to indicate relative depth
- The APL detects any pipe material but does not indicate the type or size of the pipe

**Case Studies**

**Case 1: Military Facility in South Puerto Rico - Locating an Asbestos Cement Water Line**
A utility sweep was performed at the facility to determine and validate the existing potable water distribution system. Approximately 40% of the water line is made of asbestos cement and covered with clay material. Although site plans and facility personnel showed the approximate water line location, GPR did not detect it. After the unsatisfactory results using GPR, GeoEnviroTech’s company yard. Due to clay soils and utility depth, GPR was not able to detect the line. The Ultra-Trac APL was able to detect the sewer line and trace it back to the intake headwall. The asbestos cement water line at the military base was located approximately three to four feet below ground. As part of a water development plan at the facility, the actual potable water system had to be identified using geophysics technology in a Quality Level A (QL-A).

In this case, the use of conventional RFE locating equipment was not possible since the target material was non-metallic asbestos concrete. Initially, GPR appeared to be the right technology for this job. However, the soil consisted of sandy clay from zero to two feet followed by fat clay, causing the attenuation of the GPR signal. Only the waterline trench was detectable at some locations using GPR. However, the SENSIT APL successfully located the asbestos cement water line.

**Case 2: Military Facility in South Puerto Rico, PVC Water Line**
This water line was located approximately 2 to 3 feet below ground surface. The use of RFE equipment was not possible since the water line construction material was non-metallic (PVC). Use of GPR was not possible because a PVC water line was located at approximately 14 to 18 inches from a chain-link fence. This fence caused signal interference and affected the GPR response. Also, the fence provided no clearance to run the GPR over the target. However, the SENSIT APL was able to detect the water line, which was later confirmed using vacuum excavation.
Case 3: GeoEnviroTech’s Business Premises Located in the Countryside to the Northern Side of Puerto Rico

The storm water line was located approximately five to six feet below ground surface. Use of RFE equipment was not possible here since the water line construction material was concrete. GPR appeared to be the right technology for this job. However, once on site, it was determined that the local soil consisted of fill material for the first foot, followed by thick clay. The GPR signal was highly attenuated, and only the storm water line trench was detectable at some locations. Once again, the SENSIT APL was able to detect the plastic storm water line when all other technologies could not.

Conclusion

Different soil conditions such as groundwater table, soil types, fill materials and depth of the buried objects can limit the performance of both Ground Penetrating Radar and Radio Frequency Electromagnetics. Although GPR and RFE are generally great tools for locating buried utilities, the use of a SENSIT APL greatly improves utility locating capabilities in detecting non-metallic objects such as PVC, HDPE and asbestos cements pipes. There is not a single locating technology that can locate everything, in every soil and site condition. Deploying all three technologies, including the use of acoustic locating technology via the SENSIT APL, greatly reduces the risk of damaging a line.

GeoEnviroTech, Inc. is a utility locator and drilling company based in Guaynabo, Puerto Rico covering the Caribbean and Central America. They employ GPR units from Sensors & Software, RFE locators from Rigid, Vivax and Pipehorn, and the Ultra Trac APL acoustic pipe locator from SENSIT Technologies. Other supplemental equipment includes Fisher and Vivax metal detectors, and vacuum excavation.

Author Juan D. Negrón-Hernández is Principal Geologist and President of GeoEnviroTech, Inc.